tain or increase the BMD, thereby reducing the future fracture risk. Lifestyle changes and appropriate medical therapy have been shown to increase the BMD and to reduce fracture risk.

Almost all approved drugs act by reducing bone resorption. Estrogen is still the leading drug for postmenopausal women, but alendronate sodium (a biphosphonate) and calcitonin have proven efficacies. Bone densitometry results can substantially influence decisions about beginning estrogen or other drug therapy and provide follow-up to assess the effects of therapy and future fracture risk.

JOHN M.VOGEL, MD
Sacramento, California

REFERENCES

Consensus Development Conference: Diagnosis, prophylaxis, and treatment of osteoporosis. Am J Med 1993; 94:646–650

Cummings SR, Black DM, Nevitt MC, et al: Bone density at various sites for prediction of hip fractures—The Study of Osteoporotic Fractures Research Group. Lancet 1993; 341:72–75

Kanis JA, Melton LJ III, Christiansen C, Johnston CC, Khaltaev N: The diagnosis of osteoporosis. J Bone Miner Res 1994; 9:1137–1141

Collimation Approaches to 511-keV Imaging

POSITRON-EMISSION TOMOGRAPHY (PET) using fludeoxyglucose F 18 (^{18}FDG) has proved effective in evaluating patients with coronary artery disease, especially those in whom the viability of myocardial tissue is in question. The PET evaluation of the central nervous system in various disorders including dementias, stroke, and epilepsy has been well established. Recent work with PET imaging has indicated a possible role in oncology, especially in evaluating patients with melanoma, colon cancer, lung cancer, head and neck tumors, and other tumor types including lymphoma. It is capable of detecting lesions as small as 4 to 5 mm and has been shown in several studies to be more accurate and more cost-effective than computed tomography (CT) or magnetic resonance imaging in the staging of several tumor types. The major drawback to PET imaging is that it is not always available, although the supply of PET radiopharmaceutical agents, especially ^{18}FDG, is improving.

To reduce the overall cost of using PET pharmaceuticals such as ^{18}FDG, an attempt has been ongoing to use conventional Anger camera systems for detecting 511-keV annihilation radiation. Two approaches appear to be emerging using the Anger camera. One involves the use of specially designed high-energy collimators for either dual- or triple-detector systems. The other relies on coincidence-detection circuitry installed in conventional dual-detector cameras.

Several studies have demonstrated the ability to image myocardial metabolism successfully using ^{18}FDG. In one study, 15 of 57 patients were found to have mismatched defects in which the uptake of technetium Tc 99m sestamibi was reduced whereas the use of ^{18}FDG showed normal or increased activity. This pattern was associated with ischemia. Matched defects were seen in 14 patients, consistent with myocardial scarring, and 7 had both matched and mismatched defects; 21 patients had normal studies. A total of 23 patients underwent coronary angiography within three months of the dual-isotope single-photon-emission CT (SPECT) study. Coronary artery stenosis of greater than 70% was detected using dual-isotope SPECT, with a sensitivity of 100% and a specificity of 88%. It was concluded that dual-isotope SPECT using ^{18}FDG and ^{99m}Tc-sestamibi was an excellent way to identify injured or dysfunctional but viable myocardium. Works in progress have substantiated this technique, and larger studies are now ongoing.

The use of ^{18}FDG-SPECT has been compared with that of ^{18}FDG-PET imaging in patients with coronary artery disease and those with malignant tumors. In nine patients with heart disease, the ^{18}FDG-SPECT and -PET images were shown to be comparable in diagnostic information regarding the amount of viable myocardium. In seven of eight patients, malignant tissue visualized with ^{18}FDG PET was seen equally well with SPECT. Lesions not visualized with ^{18}FDG SPECT were either small (<1.5 cm) or were benign.

Several published studies have indicated the cost-effectiveness of conventional PET imaging in oncology compared with x-ray and CT approaches. The sensitivity and specificity of PET far exceed those of CT, making it cost-effective to include or exclude patients from surgical procedures using PET.

There are little published data to support the oncologic use of Anger camera-collimated systems for imaging 511-keV pharmaceuticals. The resolution for older Anger camera-collimated systems has been limited thus far by highly inefficient sodium iodide detectors for 511-keV energies. Poorly shielded systems, energy-resolution limitations for 511-keV, and resolution limitations of existing collimators were problematic. Lesions smaller than 12 mm are seldom detected. The resolution of 511-keV imaging for myocardial perfusion for assessing viability, however, appears to be good, and the technique is now clinically useful. Recent advances in camera design, including more efficient detectors, improved collimator designs, and better energy resolution have improved image quality to the point where some institutions are beginning to obtain PET-quality images with ^{18}FDG SPECT.

Anger camera detectors with coincidence-detection circuitry have recently been evaluated. Clinical trials have shown PET-quality images for oncologic applications. As instruments improve, applications will grow in oncology as well as in cardiology. Neuroimaging is competing with excellent SPECT brain imaging techniques using single-photon neuroperfusion agents. Thus, development is likely to be slower with regard to Anger camera PET radiopharmaceutical agents for brain imaging.

The feasibility of detecting tumor using the Anger camera has clearly been demonstrated, and this technique may prove useful, especially in evaluating pancreatic

masses, recurrent colon cancer, melanoma, lymphoma, head and neck tumors and other tumor types now being evaluated.

ALAN D. WAXMAN, MD
Los Angeles, California

REFERENCES

Drane WE, Abbott FD, Nicole MW, Mastin ST, Kuperus JH: Technology for FDG SPECT with a relatively inexpensive gamma camera. Radiology 1994; 191:461–465

Martin WH, Delbeke D, Patton JA, et al: FDG-SPECT: Correlation with FDG-PET. J Nucl Med 1995; 36:988–995

Martin WH, Delbeke D, Patton JA, Sandler MP: Detection of malignancies with SPECT versus PET, with 2-[fluorine-18] fluoro-2-deoxy-D-glucose. Radiology 1996; 198:225–231

Sandler MP, Videlefsky S, Delbeke D, et al: Evaluation of myocardial ischemia using a rest metabolism/stress perfusion protocol with fluorine-18 deoxyglucose/technetium-99m MIBI and dual-isotope simultaneous-acquisition single-photon emission computed tomography. J Am Coll Cardiol 1995; 26:870–878

Detection and Localization of Gastrointestinal Bleeding

SUCCESSFUL TREATMENT of gastrointestinal bleeding depends on the accurate detection and localization of the actual bleeding site. Angiography can diagnose and possibly treat a bleeding site if the patient is actively bleeding during the examination at a rate of 1 ml or more per minute. Most patients bleed intermittently, however; therefore, angiography may fail to detect the bleeding site. Scintigraphy, on the other hand, can determine whether a patient is actively bleeding and help to localize the bleeding site. Foreknowledge of the approximate bleeding site allows an angiographer to tailor an examination, thereby decreasing the time of an examination, the amount of contrast medium required, and a patient's radiation exposure.

Two scintigraphic techniques are available for detecting lower gastrointestinal bleeding: technetium Tc 99m sulfur colloid and technetium Tc 99m-labeled erythrocyte (^{99m}Tc-RBC) scans. After 370 to 550 MBq of ^{99m}Tc-sulfur colloid is administered, flow images of the abdomen and pelvis are acquired, followed by sequential static or dynamic images for 20 minutes. The presence of intraluminal activity that increases with time and is seen to move within the bowel indicates acute gastrointestinal bleeding. ^{99m}Tc-Sulfur colloid scans can detect active bleeding rates as low as 0.05 to 0.1 ml per minute. Although the ^{99m}Tc-sulfur colloid scan is the most sensitive method for detecting gastrointestinal bleeding, it will detect hemorrhage only if the patient is actively bleeding during the brief imaging time of the study. The role of ^{99m}Tc-sulfur colloid scans is limited to cases of unstable patients bleeding acutely where rapid localization of the bleeding site before surgery or angiography is necessary or where labeling erythrocytes is not feasible.

^{99m}Tc-Labeled erythrocyte scans (740 to 915 MBq of activity) are performed by acquiring flow images, followed by sequential static or dynamic images for 60 to 90 minutes or until bleeding is confirmed. These scans demonstrate bleeding rates as low as 0.1 to 0.2 ml per minute. To detect intermittent bleeding, delayed imaging may be done as long as 24 hours after the ^{99m}Tc-RBC is administered. The recent release of a commercially available in vitro kit with a labeling efficiency of greater than 98% has improved accuracy. High labeling efficiency of the tagged erythrocytes is necessary because free sodium pertechnetate Tc 99m can simulate acute hemorrhage. Therefore, erythrocyte labeling should be done using either the in vitro kit or a routine in vitro technique. Precise static localization of the site of bleeding may be problematic with ^{99m}Tc-RBC scans because blood may move antegrade or retrograde within the bowel. The technique of dynamically viewing acquired bleeding studies in a cinematic loop has improved the accuracy of localizing bleeding sites.

A comparison imaging study was done of 100 patients with lower gastrointestinal bleeding in which a ^{99m}Tc-RBC study immediately followed the use of a ^{99m}Tc-sulfur colloid scan. The ^{99m}Tc-sulfur colloid scan detected only 4 cases of bleeding whereas the ^{99m}Tc-RBC scans found 38. The sensitivity of the ^{99m}Tc-RBC scans was 93%, specificity 95%, and accuracy 94%.

In conclusion, a cinematic ^{99m}Tc-RBC scan is the study of choice for the scintigraphic evaluation of lower gastrointestinal bleeding. Scintigraphy can be used to detect active bleeding and to localize the bleeding site before expensive and invasive procedures such as angiography and surgery are done.

RHONDA A. WYATT, MD
Fairfield, California

REFERENCES

Alavi A, Worsley D: Scintigraphic detection and localization of gastrointestinal bleeding sites, chap 40, *In* Sandler MP, Coleman RE, Wackers FJ, et al (Eds): Diagnostic Nuclear Medicine—Vol 2, 3rd edition. Baltimore, Md, Williams & Wilkins, 1996, pp 801–821

Kostamo KL: Evaluation of gastrointestinal bleeding by nuclear medicine techniques, chap 70, *In* Henkin RE, Boles MA, Dillehay GL, et al (Eds): Nuclear Medicine—Vol II. St Louis, Mo, Mosby, 1996, pp 1016–1022

Mauer AH: Gastrointestinal bleeding, chap 5, *In* Murray IP, Ell PJ (Eds): Nuclear Medicine in Clinical Diagnosis and Treatment—Vol 1. New York, NY, Churchill Livingstone, 1994, pp 47–54

Maurer AH: Gastrointestinal bleeding and cine-scintigraphy. Semin Nucl Med 1996; 26:43–50

Zuckerman DA, Bocchini TP, Birnbaum EH: Massive hemorrhage in the lower gastrointestinal tract in adults: Diagnostic imaging and intervention. AJR Am J Roentgenol 1993; 161:703–711